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NOTE

Biological Notes on *Heriades carinatus* Cresson, *Heriades leavitti* Crawford, and *Heriades variolosus* (Cresson) (Hymenoptera: Megachilidae)

Biological information is available for three of the 13 North American species of the bee genus *Heriades* Spinola (Megachilidae: Osmiini) (Griswold 1985): *Heriades carinatus* Cresson (Rau 1922; Matthews 1965; Krombein 1967; Jensen et al. 2003), *Heriades leavitti* Crawford (Krombein 1967), and *Heriades variolosus* (Cresson) (Fischer 1955). Here, we describe the structure of *H. carinatus* nests in Montana and compare it to observations from other locations. For all three species, we add data on emergence sex ratios, and for *H. leavitti*, we report records for nest associates, including *Sapyga* spp. (Sapygidae).

To construct trap-nests, we drilled 15 cm long holes of varying diameter into pine boards and then inserted paper tubes with internal diameters of 3.2, 3.7, 4.6, 5.9, 7.5, 8.0, and 9.0 mm. Nest boards, with the nest holes facing southeast, were placed adjacent to trees at heights of 1.5–2.0 m at sites in Gallatin Co., Montana, during the last week of May 1999 and 2000 (by PDJ and KMO) and Seneca Co., New York, on 16 May 2002 (by KMO and JFO). We collected completed nests and held them at room temperature until late fall each year when they were transferred to a 8°C /85% relative humidity cold room. The following April, nests were returned to room temperature for post-diapause rearing.

Heriades carinatus.—We found *H. carinatus* in trap nests at seven sites in Gallatin Co., Montana: 1) 13 km S. of Three Forks along the Madison River; 2) 5.2 km north of Logan along an intermittent stream; 3) 3 and 5 km northeast of Norris along a stream; 4) 5 km northeast of Manhattan along a Bullrun Creek at the edge of a pasture on Fulker Farm; 5) 4 km south of Bozeman along Hyalite Creek; 6) 3 km east of Bozeman between a stream and a cultivated field on Rocky Creek Farm; and 7) Bozeman at the Montana State University Horticultural Farm. Most *H. carinatus* nested in 3.2 and 3.7 mm diameter tunnels. Of the 254 emerging *H. carinatus* adults that we could associate with nests of known diameter, 105 came from 3.2 mm nests, 134 from 3.7 mm nests, ten from 4.6 mm nests, three from 5.9 mm nests, and one each from 7.5 and 8.0 mm nests. Matthews (1965) found that *H. carinatus* usually nested in 3.1 mm holes in Michigan and 3.5 mm holes in Oregon, differences between the sites being attributable to the different sizes of trap-nests placed in the two locations. When Krombein (1967) provided trap-nests ranging from 3.2–12.7 mm in diameter, *H. carinatus* used only the two smallest hole sizes, 3.2 and 4.8 mm. Thus, the choice of nest hole sizes appears to be relatively constant among populations.

Of the ten nests dissected, seven contained only *H. carinatus* cells, whereas three also contained cells of *Trypoxylon* (*Trypoxylon*) sp. (Hymenoptera: Crabronidae). The latter included one nest with two *H. carinatus* cells outside of five *Trypoxylon* cells, one with four *H. carinatus* cells outside of two *Trypoxylon* cells, and one with two *Trypoxylon* cells outside of one *H. carinatus* cell.

The inner portion of seven completed *Heriades*-only nests included a basal space (0–69 mm long; mean ± SE = 19.3 ± 9.8). Next, was a sequence of 2–9 contiguous brood cells (mean = 5.4 ±

1.1 per nest), 6–13 mm long (mean = 8.8 ± 3 mm; N = 36). Each cell was delineated from others and from the basal space by 1–2 mm thick partitions of plant resin, but cells were not lined with any visible material. The final cell in each nest was followed by one (N = 4) or two empty "vestibular" spaces. When two vestibular spaces were present, they were separated from each other by a 1–3 mm thick resin plug. The total vestibular space, including that in nests in which *Heriades* superseded *Trypoxylon*, ranged from 22–122 mm (mean = 66.3 ± 12.0 mm). Each of the nine nests finished by a *Heriades* female was capped with a final 3–7 mm thick resin plug (mean = 4.8 ± 0.5 mm). Overall, 34.0 ± 7.5% of space in *Heriades*-only nests was devoted to brood cells and their partitions, with empty space comprising 62.5 ± 7.8% and the final plug 3.5 ± 0.4%. Matthews (1965), who provided shorter nest tunnels, reported no basal spaces in *H. carinatus* nests, so that the initial cells were either directly against the inner end of the boring or against a resin plug placed at the inner end. Like Krombein (1967), we found no plugs delineating the inner border of basal spaces. Matthews and Krombein both reported vestibular cells, although they were absent in 13% of 89 nests examined by Matthews. The range in the number of cells in Montana nests was nearly identical to that seen by Matthews (1965) in Michigan. Because nest holes were shorter in Michigan, the similar number is likely due to lack of a basal space in Michigan nests. The greater number of cells Matthews observed in Oregon (mean = 6.4, range: 2–13), was offset by shorter vestibular cells.

Sex ratios of emerging *H. carinatus* from all Montana sites combined were highly skewed towards females in 3.2 mm nests (94.4% female, N = 108; $\chi^2 = 85.3$, $P < 0.001$) and 3.7 mm nests (78.1% females, N = 137; $\chi^2 = 43.3$, $P < 0.001$). The 15 bees that emerged from 4.6–8.0 mm nests included nine females ($\chi^2 = 0.60$, $P > 0.50$). No one site produced less than 74% females. Another group of nests, for which we did not record the diameter of tunnels from which each bee emerged, produced 83.9% females (N = 155, $\chi^2 = 71.1$, $P < 0.001$). The strong and consistent bias towards females contrasts with Matthews (1965) results from Michigan where he observed emergence sex ratios of 26% females in 1963 (N = 57, $\chi^2 = 12.8$, $P < 0.001$) and 71% females in 1964 (N = 21, $\chi^2 = 3.86$, $P < 0.05$) (our analysis of his data). In trap-nesting species, it is common for cells constructed for daughters (inner cells) to be larger than those made for sons (Krombein 1967). However, we found no correlation between cell position and cell length (Spearmann rank correlation, $P = 0.82$; N = 36) and no difference between the length of the innermost and outermost cell in each nest (Wilcoxon Signed Rank Test, $P = 0.09$). Similarly, Matthews (1965) found no difference in the size of male and female *H. carinatus* cells, although females tended to occupy inner cells.

Heriades leavitti.—The single previous report of *H. leavitti* nests was by Krombein (1967), who found five nests at Lake Placid, Florida, all in 3.2 mm diameter tunnels; he reared just one individual of each sex from nests, and found no nest associates. In 2002, we found *H. leavitti* in seven 3.2 mm nests along the south edge of the North Pool at Montezuma National Wildlife Refuge, Seneca Co., New York. This extends our knowledge of the distribution of *H. leavitti*, which had not been previously reported in New York State (Hurd 1979; J. Ascher, personal communication). The nests produced 25 adult female and 18 adult male *H. leavitti* ($\chi^2 = 1.14$, $P > 0.10$), but five nests also had other occupants (Table 1). The single nest that we dissected contained ten cells whose

Table 1. Contents of *H. leavitti* nests from the Montezuma National Wildlife Refuge.

Nest number	*Heriades leavitti*		Other Nest Occupants
	Males	Females	
1	0	5	*Hylaeus annulatus* (L.)[1] (5 ♂, 3 ♀); *Sapyga* sp.(1 ♂, 2 ♀)
2	0	1	*H. annulatus* (2 ♂)
3	4	0	
4	3	7	*Sapyga louisi* Krombein (1 ♂, 2 ♀)
5	4	10	
6	5	1	*S. louisi* (4 ♀)
7	2	1	*H. carinatus* (2 ♀)
Total	18	25	

[1] = *Hylaeus ellipticus* (Kirby) (Colletidae).

contents, beginning with the innermost cell, were: one female *S. louisi*, one female *H. leavitti*, four male *H. leavitti*, three female *S. louisi*, and one male *H. leavitti*. In North America, *Sapyga* have been reported attacking only Megachilidae (Krombein 1979), so it seems likely that they attacked *Heriades* rather than *Hylaeus* in our nests. If so, *Sapyga* spp. infested 18% of the *Heriades* cells in NY. This is higher than the overall rate reported by Matthews (1965), who observed *S. louisi* in 0.4% of *H. carinatus* cells, but much lower than the maximum rate of 74% for *Sapyga pumila* Cresson attacking *Megachile rotundata* (L.) (Torchio 1972); in the latter case, however, bees cells were at extremely high densities in populations managed to aid alfalfa pollination.

Heriades variolosus.—Two nests collected in 1999 from the Fulker Farm in Montana were occupied *by H. variolosus*. One male and 11 females emerged from a 3.2 mm nest, and five females emerged from a 3.7 mm nest. A 5 mm nest collected in 2000 produced one male *H. variolosus*. The only previous report on this species was that of Fischer (1955) who found a single five-celled nest in hollow sumac (*Rhus glabra* L.) stem with a bore diameter of 3 mm.

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